# ALPHA-INDUCED REACTIONS ON $^{59}$Co

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The mechanism of alpha-induced reactions on $^{59}$Co is presently being studied by both in-beam and off-line $\gamma$-counting techniques in the energy range from 20 to 200 MeV. To date, we have measured absolute cross sections for the production of residual nuclei, $\gamma$-$\gamma$ coincidences, and recoil ranges at bombarding energies of 82, 127 and 133 MeV. The cross sections were obtained by summing absolute intensities of $\gamma$-transitions leading to the ground state (or, in some cases, low excited states) as measured in a Ge(Li) detector positioned at 90° with respect to the beam direction. Details of the experimental technique are given in Ref. 1.

The mass distribution of the observed residues is shown in Fig. 1 for the three bombarding energies. In all cases, at least 80 percent of the observed cross section belongs to residual nuclei of $\Delta A = A_{CN} - A_{RES}$ between 4 and 9. The mass distributions for alpha-particle bombarding energies of 127 and 199 MeV are similar; however, the higher energy data exhibit a longer tail extending toward larger values of $\Delta A$.

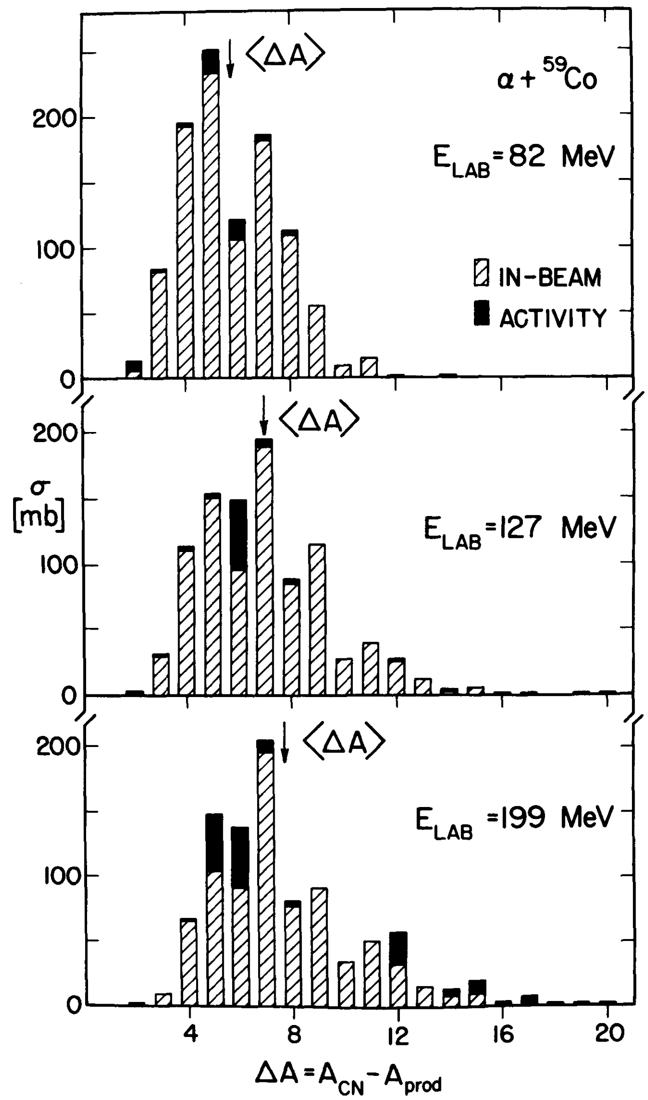


Figure 1. Distribution function for $\Delta A$, the mass emitted from the composite system, for the $\alpha$+$^{59}$Co reaction. The arrow indicates the position of the average mass removed, $\langle\Delta A\rangle$.

The average number of nucleons emitted from the target plus the projectile composite system $\langle\Delta A\rangle$ is shown in Fig. 2 as a function of excitation energy (calculated assuming compound nucleus formation) for alpha-particle as well as for proton and $^{6}$Li induced reations investigated previously at IUCF.[1-3] The average value, $\langle\Delta A\rangle$, changes very slowly with alpha-particle bombarding energy between 80 and 200 MeV, and behaves in a manner very similar to that for proton-induced reactions. This indicates that there are large contributions to the observed cross sections from processes in which the emission of fast particles precedes equilibration of the composite system.

Recoil-range measurements[3] confirm this observation. Results for a few selected residues are

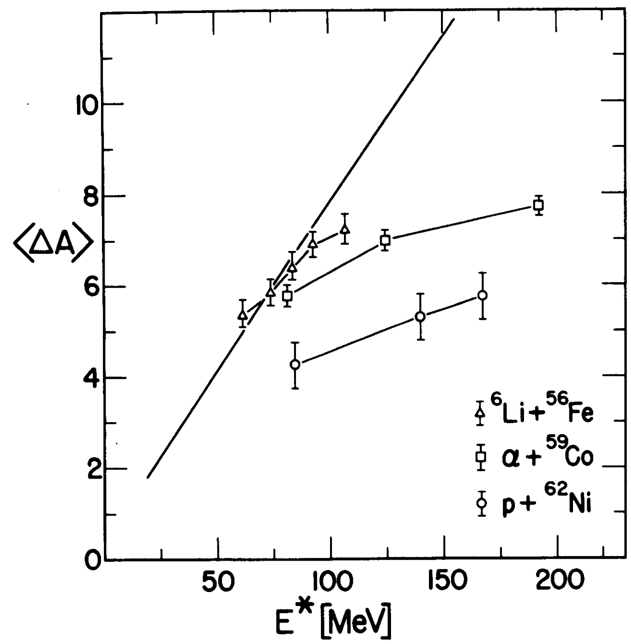


Figure 2. ⟨ΔA⟩ as a function of the excitation energy for $^6Li+^{56}Fe$, $\alpha+^{59}Co$, and $p+^{62}Ni$ reactions. The solid line represents the results of the statistical model calculations using ALICE code with parameters described in Ref. 1.

shown in Fig. 3. One can see that at 80 MeV alpha bombarding energy nuclei such as $^{48}V$ and $^{52}Mn$ are formed mainly by evaporation processes since they have recoil ranges close to those calculated for the compound nucleus (solid curve). The smaller ranges for the Co nuclei indicate that the processes leading to their formation involve emission of fast particles which carry away a large part of the incident momentum. This effect becomes more pronounced at higher bombarding energies. In other words, pre-equilibrium emission becomes relatively more important at higher energies.

Further measurements, mainly at lower alpha-particle bombarding energies, will be performed in the near future. Results of this experiment will be compared with calculations using an intra-nuclear cascade model.[2-4]

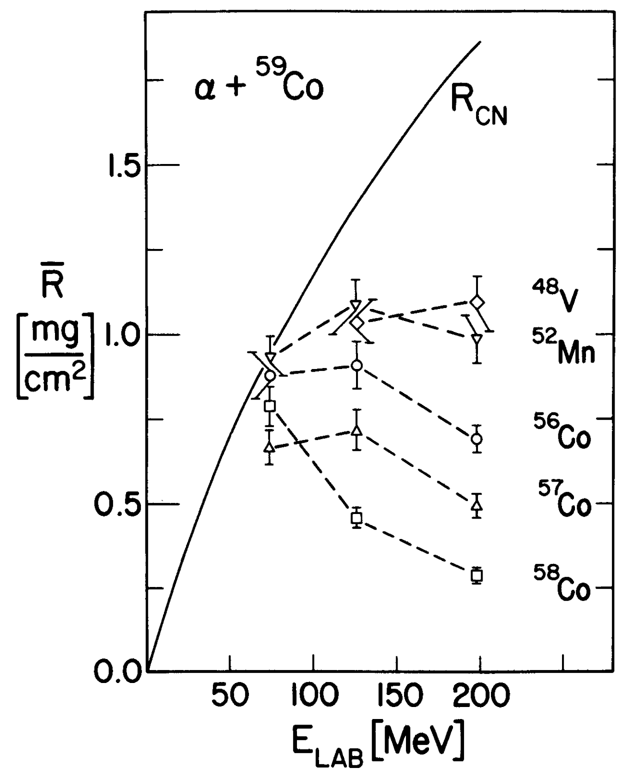


Figure 3. Projected recoil ranges, $\bar{R}$, as a function of the alpha particle bombarding energy. The solid line is calculated assuming that the compound nucleus energy, $E_R(CN)$, is equal to $A_PA_TE_\alpha/(A_P+A_T)^2$, where $E_\alpha$ is the projectile kinetic energy and $A_P$ and $A_T$ are the projectile and target mass, respectively.

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